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Assume [12–14] and mass aggregation models [15–20]. Many of these models - where there is a conservation law or, in case of violation, the law is weakly violated in the sense that the systems are slowly driven - are intimately connected to each other. For example, the mass aggregation models [17–19, 21] are connected to directed abelian sandpile model [22] or to the models of river network [2].

In this paper, we argue that power-law distributions in out-of-equilibrium systems can arise simply from additivity property, the tenet of equilibrium thermodynamics. We find that the divergence in the response function is the key: Diverging fluctuations can, in principle, arise from distributions other than power laws, which are however prohibited if one imposes additivity and consequent fluctuation-response (FR) relation. The response function determines the full scaling form of the distribution, at as well as away from criticality, and critical exponents

$m^{-5/2}$ power law, at or away from criticality, appears so often in mass aggregation models - especially in higher dimensions, at all densities and irrespective of that the motion of the diffusing masses is biased or not [19, 21, 23, 24]. Interestingly, the same power law appears in k -mer distribution in the classic Flory-Stockmayer [25] theory of polymerization and also in particle number distribution in three dimensional ideal Bose gas near critical point, irrespective of whether the systems are in or out of equilibrium - thus indicating a *universality*. We demonstrate that the $m^{-5/2}$ law is a consequence of a simple-pole singularity in the variance. The whole analysis is extended also to nonconserved mass aggregation models. We validate our theory by explicitly calculating mass distributions in previously studied mass aggregation models and their variants and by comparing them with simulations.

Organization of the paper is as follows. In section II.A, we discuss additivity property; in section II.B, we discuss the connection between singularity in the variance and the asymptotic behaviour of the mass distribution func-